Integrating Local / Traditional Ecological Knowledge into Fisheries Management in Canada

Final Report

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EXECUTIVE SUMMARY

The following report, commissioned by the Integrated Coastal Zone Management program of the Marine Ecosystems Conservation Branch, Fisheries and Oceans Canada (FOC), provides pragmatic advice on how to accomplish effective integration of Local-Traditional Ecological Knowledge (LO-TEK) with conventional science in fisheries management.

The first section discusses the differences and similarities between the LO-TEK and conventional science, and the need for a synthesis between them in order to provide appropriate data to government managers involved in Integrated Coastal Zone Management efforts.

The second section provides a review of relevant literature on co-management arrangements, which the author argues provide the most appropriate political form for integrating the needs of local communities and those of coastal ecosystems. Including LO-TEK on an equal footing with conventional science is essential to successful co-management arrangements, while conversely, the power-sharing represented by co-management is a precondition to its successful integration.

The third section compares LO-TEK-based ecological micro-management (EMM) and the new concept of "parametric management", arguing that parametric management provides the rationale for a more serious look at LO-TEK in fisheries management, and a more active role for local resource users in analysis, enforcement and mitigation..

Finally, the literature on resolving contradictions between LO-TEK and conventional science, as well as gaining access to LO-TEK in local communities is reviewed, and a concluding section summarizes the report in context of the new Ocean Act of 1997.

INTRODUCTION

The past decade has seen an explosion of interest in and attendant research into what is referred to in this report as Local and Traditional Ecological Knowledge (LO-TEK) . As will be explored at length in the pages to follow, this interest is driven by a number of distinct yet inter-related issues. Those issues of direct interest to fisheries managers and researchers include the failure of centralized, large-scale systems of marine resource management to maintain healthy and sustainable levels of the resources in question, growing problems of non-compliance with harvest regulations by subsistence and commercial users, jurisdictional disputes between federal, provincial and aboriginal governments, growing interest in integrated resource management, which takes into account the ecological context of resource harvesting, and shrinking budgets for management, research, and enforcement of regulations.

Dozens of studies by anthropologists, sociologists, resource economists, geographers and ecologists have demonstrated that knowledge systems developed over generations by indigenous and non-indigenous local communities can provide data superior in many regards to that available through

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conventional scientific research methods. Moreover, it has been demonstrated that compliance with regulations is markedly improved when local communities are involved in their development and enforcement, especially where it can be seen that LO-TEK has been integrated with conventional science in management decisions. Such an integration is, however, problematic in many respects.

Despite the immense volume of research into the validity and applicability of LO-TEK for marine and other natural resource management, relatively little has been written regarding the practical considerations for merging LO-TEK with conventional science. Of particular concern is how possible contradictions between the two knowledge systems can be resolved. This report, commissioned by the Integrated Coastal Zone Management program of the Marine Ecosystems Conservation Branch, Fisheries and Oceans Canada (FOC), provides pragmatic advice on how to accomplish effective integration of LO-TEK with conventional science.

The first section defines, compares, and contrasts LO-TEK and conventional science, identifying commonalties that can serve as a basis for a productive engagement between the two knowledge systems, and highlighting differences that must be taken into account in order to minimize conflict. LO-TEK and conventional science each have their own special competence at varying geographical levels, and insights from both knowledge systems can reciprocally improve fisheries management.

Since the integration of LO-TEK and conventional science is inextricably related to questions of power sharing, the concept of co-management is explored more fully in the second section, drawing upon a number of case studies where attempts have been made to include LO-TEK into co-management regimes. It is clear from these studies that where LO-TEK has been marginalized or only superficially considered, the resource management regimes in question have been less than successful in achieving ecological and economic sustainability. By far the most successful cases have involved some degree of devolution of decision-making and enforcement authority to local groups. Co-management, while perhaps "not an altogether new paradigm" (Rettig et. al. 1989: 276) has only been put seriously into practice in recent years. While there exists no clear consensus on a standard for co-management arrangements, where LO-TEK has been meaningfully incorporated the initial results indicate significant benefits for both conservation and the minimization of conflict among users and governments.

Section three compares ecological micro-management with Acheson and Wilson's (1996) "parametric management" model. Parametric management focuses on the maintenance of ecosystemic and stock-specific parameters such as habitat and spawning recruitment rather than solely setting quota levels to ensure healthy fish populations. This model closely mirrors practices based on LO-TEK and points the way to integrating this knowledge system with conventional scientific approaches to fisheries management.

The final section summarizes recent publications dealing directly with the practical as well as theoretical aspects of integrating LO-TEK and conventional science. Taking into account the differing and sometimes overlapping geographical competence of the two systems will aid in their integration and lead to enhancement of both ecological parameters and macro-level population numbers. The overriding conclusion drawn by LO-TEK experts is that the integration of LO-TEK and conventional science will require fundamental changes in the approaches traditionally taken by government managers. In this regard, the report concludes with a discussion of how the Canadian Oceans Act proclaimed on January 31, 1997, may well provide the political impetus required for such changes to be implemented in the management of Canadian marine resources.

1.0 - TWO KNOWLEDGE SYSTEMS?

1.1 - Conventional Science

Conventional science has been hailed as "the supreme intellectual achievement of our society" (Salmon et. al. 1970b: 1). The contributions of natural scientists, and biologists in particular, to our understanding of natural processes and therefore our ability to manage human use of natural resources are far too numerous to exhaustively list here. Johnson (1992) argues that the flexibility of scientific analysis provides us with the unprecedented ability to view phenomena either microscopically or telescopically, and that these abilities allow management at scales beyond the grasp of traditional societies. She suggests that conventional science has three primary characteristics. The first is reductionism, where understanding complex phenomena is achieved by breaking down data and reassembling it in different ways. This approach enables the rapid accumulation of data, and allows for the development of what DeWalt (1994) calls "immutable mobiles", or "information that can be transferred [and applied] without any transformation to any spatial or social location" (p. 124). The second characteristic Johnson identifies is objectivism, or the belief that observers must deliberately separate themselves from the observed in order to obtain accurate knowledge. Such an approach is taken in order to guarantee that subjective values and preferences do not contaminate the results of research; that the facts should, as it were, speak for themselves. Thirdly, science is positivist, or based on the belief that the proof of any proposition is in the method of its verification, or put another way, that anything measurable is scientifically real, and that what is scientifically real can be measured. As such, scientists are suspicious of knowledge systems in which "superstitious" explanations of phenomena are given; where, for example, the decline in the population of a given species is explained as being the result of "the anger of the gods". The positivism of science has ensured that testable hypotheses rather than metaphysical theories hold sway in the development of knowledge about the external world, and that in theory at least, in most cases this knowledge achieves greater correspondence with "reality" as a result.

Each of these characteristics has enabled startling advances in technology and contributed to the spread of European civilization around the world. However, in recent years, a number of problems with the application of conventional science to resource management have come to light. The first is that when scientific research is translated into policy decisions, political considerations are sometimes given priority over the hard results of scientific research. Scientists employed or funded by governments are sometimes discouraged from pursuing certain avenues of research, or the results of research are suppressed through implicit threats of dismissal or demotion (Professional Institute of the Public Service of Canada 1998). As a result, discrete scientific "facts" are picked and chosen by policy makers without adequate regard for their context or for ecological realities. A second problem is that while in theory a scientific approach should ultimately provide a complete explanation of all bio-physical phenomena on Earth, in practice there simply does not exist the funding nor the adequately trained personnel to generate the volume of data which would be required for such an objective (Acheson and Wilson 1996). As such, scientists must rely on sampling and modelling of natural phenomena in order to make predictions about future trends and phenomena in wider areas. The emerging science of ecology has shown that the sheer volume of ecosystemic interactions renders precise causal explanations and prediction impossible. At best, scientists can hypothesize, as in stock-recruitment models for example, that fish populations will change predictably according to a consistent level of fishing effort, and then make suggestions based on statistical averages for sustainable harvest quotas.

From the holistic perspective of indigenous nations and others who perceive the world as a web of complex ecological relationships, "the reductionism of science often leads to a woeful ignorance of the wider context within which the particular phenomenon under study occur... Complex systems and those characterized by myriad interactions are likely to be ignored" (DeWalt 1994: 124). DeWalt argues that reductionism is also problematic for resource management because the selection of which phenomena are to be studied is often based on the ability of researchers to break them down into researchable pieces. It also means that scientists often advocate changes to one ecosystem component without paying adequate attention to the implications for the overall system. As Svensson (1991) puts it, "white bureaucrats and technocratic experts... do not apply a holistic perspective, which is far more adequate [than reductionism]..." (p. 132). Another problem DeWalt points out is that for a

variety of reasons, limited research funding not being the least, there is a tendency for scientific investigations to focus on the short term, not looking at what the potential long-term implications of a given phenomena might be.

Critiques have also been launched at the objectivist underpinnings of conventional science. DeWalt questions "the assertion that research is value-free and that scientists need not be concerned about the ethical, social, or ecological consequences of their research" (p. 124). The notion that science is value-free has been most seriously challenged by philosopher of science Thomas Kuhn. In his book The Structure of Scientific Revolutions (1970), Kuhn argues that science textbooks ignore the history of scientific thought, a study of which would show that scientific paradigms both restrict research to specific areas and distort the results of that research to fit dominant beliefs. Changes in scientific paradigms are revolutionary and irrational in Kuhn's view, based not purely on scientific method but also on the social and political context of research.

Finally, positivism itself has been seriously challenged. Karl Popper's work, for instance, has shown that scientific facts are established by falsification, not verification (hence the concept "null hypothesis"), that science is in effect the art of establishing what we do not know (Livingstone 1992). In addition, intuitive or subconscious processes may well provide better epistemological access than rationality to knowledge about chaotic systems whose size, complexity, and temporal frame defy scientific measurement. It is this intuitive epistemology, based on very large data sets developed empirically by subjective observers over decades or generations that most clearly differentiates Local and Traditional Ecological Knowledge from conventional science.

1.2 - Local and Traditional Ecological Knowledge (LO-TEK)

The knowledge systems developed by communities of resource users over generations have been described in various terms. The most popular are "Traditional Ecological Knowledge" (TEK), "Indigenous Ecological Knowledge" (IEK), "Indigenous Technical Knowledge" (ITK), "Local Ecological Knowledge" (LEK), "Popular Knowledge" and "Folk Knowledge". This report introduces the new term "Local and Traditional Ecological Knowledge" (LO-TEK) in order to combine all of these, highlighting the fact that both indigenous and non-indigenous peoples have developed knowledge about the ecology of their local areas, and that while such knowledge has strong roots in historical experience, it is not limited to knowledge from the past. In the words of one anthropologist,

> the term "indigenous knowledge" carries the connotations of "native peoples' ideas and beliefs" and "traditional knowledge". All people, irrespective of whether they are indigenous to a given area, have developed understandings of the world that are based on their observations of their immediate surroundings (DeWalt 1994: note 1).

Moreover, as Howes and Chambers (1980) point out, the use of the word "traditional" on its own is problematic in that it denies the dynamism of knowledge production. LO-TEK is dynamic and evolving, adapted and updated almost constantly to reflect changing environmental, economic, technological and social conditions. Finally, while many LO-TEK systems may be fruitfully contrasted with the advanced and expensive technologies employed by conventional scientists for sampling and modelling, they are hardly restricted to "low-tech" approaches. Many resource user groups, and First Nations in particular, presently employ Geographical Information Systems and other complex computer software to store and analyze LO-TEK data.

The report of the World Commission on Environment and Development (WCED 1987) makes numerous references to LO-TEK and its importance in achieving ecological and economic sustainability in development. As the Commission notes, indigenous communities are "repositories of vast accumulations of traditional knowledge and experience... [The larger society] could learn a great

deal from their traditional skills in sustainably managing very complex ecological systems" (p. 114-5). The Commission urges increased efforts by all governments to fund projects to document LO-TEK and integrate it into development plans, as does the World Bank (1995). At present numerous such projects are underway, both at the international level, such as the International Research Program on Traditional Ecological Knowledge established jointly by the UNESCO Canada "Man and the Biosphere" Program and the Canadian Environmental Assessment Research Council (Inglis 1993b), at regional levels such as the Beverly-Kaminuriak Caribou Management Board (Cizek 1990), the James Bay Agreement (Berkes 1989), the Alaskan Whaling Commission (1989) and around Hudson's Bay (Nakashima 1993), and in sectors such as Environmental Impact Assessment (Johannes 1993) and fisheries management (Pinkerton 1989a; Sunderlin and Gorospe 1997; Warner 1997).

The emerging consensus is that LO-TEK generates a "wealth of empirical knowledge" (Johnson 1992) that is often superior to data gained by conventional scientific research. Howes (1980) cites numerous case studies conducted by anthropologists and taxonomists into LO-TEK, concluding that: "...the perceptions of indigenous observers are not only superior to those of the scientist as far as the identification of individual species is concerned, but that this superiority also extends to empirical understanding of localized eco-systems as a whole" (p. 337). This hardly surprising given that this understanding has often been built up over many centuries of systematic observation, whereas conventional science is comparatively new. He notes that the holistic nature of LO-TEK means that "indigenous observers possess assets in the form of empirical knowledge of the individual elements of their eco-systems, of the relations through which these elements are conjoined, and of the way in which these relations change through short and more extensive periods of time" (p. 338).

Nakashima (1993) concludes that sophisticated Inuit knowledge of animal behaviour in Hudson's Bay surpasses scientific understandings in almost all regards. As he puts it,

> The traditional ecological knowledge of Inuit is a vast and diverse resource with numerous potential applications in wildlife management. For many species of Arctic wildlife, TEK far outstrips current scientific knowledge. Yet Inuit have not gained any meaningful recognition of their knowledge in contemporary management forums" (p. 108).

In the case of the Alaskan Eskimo Whaling Commission, LO-TEK proved to be more accurate in every respect than scientific assessments of bowhead whale populations and behaviour (Freeman 1989). Similarly, the long-held belief of Sami fjord fishers that local stocks of cod migrate, like salmon, back to their birthplace has only recently been accepted by biologists (Eythorsson 1993).

Johnson (1992) identifies three facets of LO-TEK systems. The first is a system of classification, the second is a set of empirical observations, and the third is a system of self-management. Mailhot (1993) provides a richer breakdown of aspects of LO-TEK systems, including categorical (taxonomy), empirical (spatial, behavioural, anatomic, relational, interpretative), utilitarian (uses to which ecological products are put), managerial (ethics, conservation practices, measurement or observational methods), and cosmological (place of humans in nature/universe). As she describes it:

> Traditional ecological knowledge has many points in common with scientific knowledge. It is founded on the accumulation of empirical data, its methods are appreciably the same, and it relies on mental processes which accompany any acquisition of knowledge. Like science, it is an organized body of knowledge requiring a grasp of specialized concepts. It differs from science in a number of ways, however. Traditional ecological knowledge is held by the users of the resource and not by specialized researchers; it is transmitted orally and not written down; it is slower at collecting information, less ready

> to verify the predictions it makes, and more qualitative than quantitative; it often includes a spiritual dimension" (Mailhot 1993: vi-vii).

While scientific knowledge is predicated upon "a world view where society is conceived of as an entity apart from nature, able to manipulate its environment in the pursuit of its own ends" (Howes 1980: 342), LO-TEK includes "symbolic meaning" established through oral history, place names, and spiritual relationships, and operates with a cosmological understanding distinct from science/ecology in that it necessitates reciprocity toward the community, including non-humans (Berkes 1993). My own research among the Mi'kmaq of Cape Breton, while preliminary, appears to confirm this contention. The Mi'kmaq word nogamuk translates as "we are all related" and carries with it the implication that non-human organisms and even geological structures and water are enspirited and deserving of moral consideration. Morell (1989), in his analysis of Gitksan and Wet'suwet'en management of salmon harvesting on the Skeena River, British Columbia, notes that

> "In the Gitksan and Wet'suwet'en view of the world, fish and all other animals are seen as conscious beings who possess intelligence, power and spirit. The world is seen as a complex partnership in which all species have important roles to play. The partnership functions smoothly and to the benefit of all as long as all the partners perform their roles properly" (p. 232).

It is within this cosmological understanding that LO-TEK has developed what Dewalt (1994) terms "mutable immobiles", or "relatively malleable knowledge that is finely tuned to the continually changing circumstances that define a particular locality" (p. 125). Local people are very savvy about their environment and have accumulated a great deal of experience of their surroundings, resulting in a keen awareness of the interconnectedness of plants, animals, and soils - their interrelationships and ecology, but "the problem is that indigenous knowledge is very rich in contextual detail but is immobile, having little utility outside of particular places" (p. 125). It is within these "particular places" that LO-TEK has developed, and where its most important applications may be found.

1.3 - The Need for Synthesis

It is becoming increasingly clear that because of their differing yet complementary areas of competence, the synthesis of conventional science and LO-TEK would be a boon to resource management. As Howes (1980) puts it, "indigenous and scientific perspectives may diverge, but both embody important insights, thus suggesting the desirability of synthesis" (p.342). He adds that "a sizeable body of literature" suggests that the "depth and breadth" of indigenous knowledge warrants a more fundamental role for such knowledge (p. 339). Such a synthesis would acknowledge the need for both diachronic data (developed over a long time-period for a small geographical area) and synchronic data (developed over a short-time period for a large geographic area) in the making of sound management decisions:

> ...university-trained researchers create excellent synchronic data sets covering wide geographic areas (well beyond the limits of knowledge likely to be available in remote native communities). For their part, natives provide remarkably accurate diachronic data for particular localities and specific stocks of animals about which knowledge has been transmitted orally for a hundred years or more. But the two sets of data must be integrated to produce a full picture of the wildlife population dynamics and to generate assessments credible to both communities" (Osherenko 1988: 8).

For DeWalt (1994), the synthesis of conventional science and LO-TEK could lead to the development of "mutable mobiles", or "contextualized, holistic knowledge that can be adapted and applied to similar phenomena in other circumstances" (p. 128).

Due to the positivist approach of conventional science, scientists are often resistant to LO-TEK based on a suspicion of its spiritualist aspects (Johnson 1992). Yet as Roy Rappaport (1979) points out, spiritual beliefs and rituals often represent codification of functional ecological concerns. Conversely, many local communities are equally suspicious of science's reductionism and lack of cosmological concern. Humility is called for on both sides. Part of achieving the synthesis of conventional science and LO-TEK will entail cross-cultural education of both government scientists and LO-TEK holders. As Table 1 shows, although there are numerous differences between LO-TEK and conventional science, there are also broad similarities. Emphasising these similarities is a part of achieving synthesis. However, the inextricable relationship between power and knowledge (Agrawal 1995) means that synthesis will require

LO-TEK and Conventional Science Compared

Similarities	Differences
Intellectual process: Imposition of order on disorder	Data sources: LO-TEK - resource users Science - specialized researchers
Organization: Bodies of data systematized according to an internal logic	Transmission: LO-TEK - oral tradition (narratives) Science - written
Data acquisition: Empirical observation	Speed: LO-TEK - slow accumulation of information Science - rapid accumulation of information
Methods: Observation, comparison, classification	Methods: LO-TEK - does not use experimentation. Science - uses experimentation
Concepts: Nature as system of relationships	Data type: LO-TEK - diachronic (small area/long time period) Science - synchronic (large area/short time period)
Goal: Acquisition of objective knowledge	Analysis: LO-TEK - holistic, qualitative Science - reductionist, quantitative
	Ethical Underpinnings: LO-TEK - normative (human role in and responsibility toward nature) Science - value-neutral

"Rooted in different world-views and unequal in political power base.

> these two systems of knowledge are certainly not easy to combine. Serious attempts at integration inevitably come up against the question of power sharing in decision making" (p. 6).

The following section will explore this notion of power sharing at length.

2.0 - LO-TEK AND RESOURCE MANAGEMENT

2.1 - Power/Knowledge: Involving Local Communities

Two distinct global trends have led to the development of approaches to joint management of human-environment interactions by various stakeholders in specific locales, or what is commonly referred to in the literature as "co-management". The first trend is the increasing failure of large-scale industrial-state attempts to manage human use of common-property resources in manners which ensure both ecological and socio-economic sustainability. The second is the growing politicization of indigenous peoples and other residents of coastal communities. In the case of indigenous peoples (re) politicization has been accompanied by formal land claims and other demands for self-governance, while more generally, the dissatisfaction of people in coastal communities with their political and economic disempowerment relative to urban centres has led to calls for greater regional autonomy:

> There is a renewed interest in the idea of resource-dependent regions and communities achieving greater control over their own development. This shift comes at a time of global economic change which has shown the inability of governments to buffer communities against change. Community planners, development workers, anthropologists, biologists, geographers and environmental scientists have worked with such communities to develop both the theory and the practice of community-based development (Pinkerton 1989b: 7).

Coastal communities in North America and elsewhere are characterized by a heavy dependence upon the fisheries as a primary economic activity. However, centralized management systems have created a series of socio-ecological crises, exemplified in Canada by the collapse of the North Atlantic fisheries and similar looming problems in the fisheries of the Pacific coast. The traditional response of governments to perceived ecological problems has been to invoke Hobbesian metaphors such as Garret Hardin's (1968) much-cited "tragedy of the commons" or the "Prisoner's Dilemma Game" and impose strict central controls on access to natural resources (Ostrom 1990). This is an error, for as Warner (1997) points out, "Hardin later recognized that much of his characterization of the negative aspects of the commons, which according to his analysis 'remorselessly generates tragedy'... was based on a description, not of a commons regime in which authority over use of the resources resides within the community, but of an open access regime, unregulated by any external authority or social consensus" (p. 34). Winn (1991), writing about LO-TEK among Inuvialuit, concurs. Interestingly, indigenous nations such as the Haida (Richardson and Green 1989), the Gitksan and Wet'suwet'en (Morrell 1989), the Nuxalk (Hipwell 1997) and others have noticed that the imposition of harvest restrictions by states seems quite consistently to increase the relative share of the resource taken by large, commercial interests at the expense of coastal communities. For this reason and others, such centralized measures have not been successful in protecting the resources in question from further damage. It has become increasingly apparent that alternative measures are required.

In response to the two trends noted above, governments are now experimenting with co-management as an alternative to centralized control over decision making in management of human/resource interactions. The first impetus for co-management initiatives, that of the failure of centralized management systems, can be divided into either "crises of consent" (Pinkerton 1989b: 23), or "real or

perceived resource cris[es]" (Notzke 1994:169). Pinkerton notes that such crises are increasing in frequency. The second impetus, that of calls for local political autonomy, can be divided into either indigenous land claims, or non-indigenous demands for greater local control over resource allocation and decision making such as those that lead to the development of the Bella Coola Local Resource Use Plan (Hipwell 1997; LRUP Committee 1996) in British Columbia, and the "Taking Care of the Bras D'or" report recently released by the University College of Cape Breton (UCCB 1995) As Agrawal (1995) puts it, "...significant shifts in existing power relationships are crucial to development" (p 416)

Warner (1997) gives the following reasons for involving local communities in the management of marine resources:

- government departments do not have the capacity on their own to collect all the necessary data, as well as to provide ongoing monitoring and enforcement of regulations;
- the involvement of the community in data collection and management decision making leads to greater compliance of the community with regulations and results in reduced enforcement costs;
- community-based management can lead to improved biological knowledge;
- community involvement promotes a sense of collective responsibility for the sustainability of the marine resources; it allows for a better balance to be struck between present and future consumption, and between commercial and other interests;
- community involvement provides a better perspective for defining the property rights of the community;
- community involvement helps to improve the relationship between the government and the fishers;
- community involvement enhances the status of fishing and other forms of marine resources harvesting as an occupation (p. 36).

In their discussion of co-management and the fisheries, Sunderlin and Gorospe (1997) explain that a premise of co-management is that both governments and communities have "a necessary but not individually sufficient role" in management, where governments provide "administrative, regulatory and infrastructural capabilities" while communities contribute "their knowledge, their presence in the resource setting, and community-based mobilization" (334). They also note the need for devolution of management authority. Co-management does not necessarily entail the transfer any legal jurisdiction or authority; but governments must share decision-making power with local communities (Osherenko 1988).

2.2 - Co-management Defined

Berkes et. al. (1991) and others (e.g. Winn 1991) note that there is no single, widely accepted definition of co-management. At its simplest level, "[c]o-management basically involves some combination of two 'pure' management alternatives: local-level and state-level systems" (Berkes et. al. 1991: 12). The Saskatchewan Indian Federated College (1996) elaborates the concept as involving stakeholders sharing in the administration and control of natural resources, "...working together to manage a resource in a sustainable way that achieves the goals of all parties consistent with their roles" (p.1).The Royal Commission on Aboriginal Peoples (RCAP) identifies co-management arrangements as those where "governments and Aboriginal people share responsibility for resource development" (RCAP 1996: V.2, Ch. 1), though as argued here, non-indigenous communities are also appropriate sites for co-management initiatives. Many writers limit co-management to the management of use of "living" (e.g. Berkes et. al. 1991) or "renewable"(e g Winn 1991) resources, while Jacobs and Mulvihill (1995) adopt a more holistic "landscape management" understanding of management regimes.

A primary impetus for co-management is calls from coastal communities for greater political autonomy (see for example UCCB 1995). It is becoming increasingly clear that centralized decision-making

structures of states tend to exacerbate conflict among local user groups (e.g. indigenous and non-indigenous people), partly because communication tends to be vertical rather than horizontal. Such hierarchical structures are therefore less likely to result in planning that adequately addresses local economic or cultural needs, or local ecological realities. Finally, local calls for autonomy are also rooted in a distrust of externally derived "scientific" knowledge. For example, Weeks and Packard (1997) discuss the cynical attitudes of Texas ranchers and Gulf coast oyster fishers toward government scientists, and McCay (1989) notes similar initial reactions among clam fishers to scientific approaches to management. Such groups have evolved detailed and finely-tuned, empirically derived LO-TEK which in many cases contradicts scientific assumptions. This distrust of science is even more evident in indigenous nations where there exist sophisticated and ancient systems of LO-TEK

A primary impetus for co-management is calls from coastal communities for greater political autonomy (see for example UCCB 1995). It is becoming increasingly clear that centralized decision-making structures of states tend to exacerbate conflict among local user groups (e.g. indigenous and non-indigenous people), partly because communication tends to be vertical rather than horizontal. Such hierarchical structures are therefore less likely to result in planning that adequately addresses local economic or cultural needs, or local ecological realities. Finally, local calls for autonomy are also rooted in a distrust of externally derived "scientific" knowledge. For example, Weeks and Packard (1997) discuss the cynical attitudes of Texas ranchers and Gulf coast oyster fishers toward government scientists, and McCay (1989) notes similar initial reactions among clam fishers to scientific approaches to management. Such groups have evolved detailed and finely-tuned, empirically derived LO-TEK which in many cases contradicts scientific assumptions. This distrust of science is even more evident in indigenous nations where there exist sophisticated and ancient systems of LO-TEK

> particularly in parts of the continent such as the Canadian Maritime Provinces, where sabotage tends to become institutionalized... can be far more costly and inefficient than the alternative of bringing fishermen into the data-gathering and analysis process (p. 13).

Among indigenous communities, this crisis of legitimacy is even more acutely apparent. The experience of indigenous communities during a "lengthy and pervasive colonization process" has been bitter (Lee 1992). The Royal Commission on Aboriginal Communities (1996a) describes the alarming conditions among indigenous peoples in Canada, including exceptionally high levels of unemployment, incarceration, disease, and poverty (RCAP 1996b: 5) which have resulted from state policies.

Recent developments regarding aboriginal-government relations in Canada and the U.S. underscore the need for an integrated and co-operative approach to resource management. In most cases, treaties grant First Nations rights to harvest resources on so-called "publicly-owned" or "Crown" lands. Where treaties were not signed, or where the treaties did not explicitly cede territory to the Crown, these rights have been interpreted as including outright ownership. The Supreme Court of Canada's December 11, 1997 ruling in the Delgamuukw case, and the New Brunswick Court of Queen's Bench ruling earlier that autumn in the Thomas Paul case established that First Nations have extensive land rights not previously acknowledged. Moreover, a 1996 court decision in the Middle Shoals Dredging case in Cape Breton, Nova Scotia showed that the federal government has a fiduciary responsibility to safeguard natural resources used by First Nations. In the United States, indigenous treaty rights to fish have been interpreted in U.S. vs. Washington as including the right to protect fish habitat from degradation, a decision which Pinkerton (1989b) notes has had a sustained impact on the relationship between fishers and hydro-electric companies, irrigators, logging and mining companies, and oil transportation interests (p. 11). Usher (1991) poses a simple, but powerful question: "Can fisheries authorities impose restrictions on aboriginal fishing if at the same time, through insufficient application or enforcement of the law, fisheries stocks are being diminished or polluted by forestry, mining, or other industrial activities?" (p 20).

One of the limitations of many past attempts at co-management is that they have reproduced the

reductionism of conventional science by tending to focus on one species such as clams (McCay 1989), lobster (Kearney 1989), caribou (Cizek 1990), etc. While such a single-species focus does not necessarily prevent success (where success is defined as an improvement over the pre-co-management status quo), it does not allow for the full development of horizontal communication among potentially conflicting user groups. Thus, in order for co-management to be effective, it should be integrated, where multiple uses and resources are considered, and membership is not limited to extractors of "living" resources.

Co-management can reduce conflict both among local users and between local communities and State governments by enabling non-hierarchical, horizontal exchanges of information and negotiation, often along unexpected lines. Where decisions are made locally, "conflict and competition are not eliminated, but they are brought to a level where [these] decisions have a better chance of being equitable, appropriate, and acceptable" (Pinkerton 1989b: 22). For example, in the Mi'kmaq gaspereau fishery, local harvesters are more likely to be aware of micro-level impacts of shore-line developments and off-shore fisheries. A structure that would allow these harvesters to communicate their concerns directly to government managers and create a formal framework for negotiation would increase the likelihood of local-level compromises that avoid the cumbersome and expensive use of centralized regulation.

Unfortunately, not all so-called co-management regimes have effective decentralized decision-making structures. Doubleday (1989) and Winn (1991) argue that the Inuvialuit Final Agreement, though allowing for greater participation by Innuit harvesters in resource-use decision, remains dominated by the Canadian government, and has failed to adequately incorporate Inuit LO-TEK. In the case of the Wendaban Stewardship Authority, members of the Committee were frustrated by interference from the Ontario Provincial Government in the Authority's functioning (Shute and Knight 1995: 110). Similarly, under the James Bay Agreement, which is otherwise cited as one of the more successful examples of co-management, the Québec Minister responsible can arbitrarily reject recommendations by the Hunting, Fishing and Trapping Co-ordinating Committee (Berkes 1989: 203).

Just as co-management is unlikely to be successful unless it affords a prominent position to LO-TEK insights, neither are managers likely to be successful in integrating LO-TEK into their efforts without the devolution of power represented by co-management. If the goal is co-management, then LO-TEK must be included on an equal footing with conventional science. If the objective is the integration of LO-TEK into resource management, then that management regime must empower local communities at all stages of planning, implementation and enforcement.

I would suggest the following definition of a co-management body:

A formal structure for the joint administration of all resource-uses, and activities that can impact resource use through ecological impacts, in a watershed or eco-geographical region, involving a clear majority of local representatives, with equal status afforded to LO-TEK and conventional science, and given fully decentralized, consensus-based decision making power.

3.0 - TOWARDS A NEW PARADIGM IN FISHERIES MANAGEMENT

For government fisheries managers, access to a steady and reliable flow of micro-level data on fish populations, reproductive rates and harvest levels, as well as the confidence that harvesting was closely regulated in all areas, would enormously enhance their management capabilities. Yet the enormous budget required to hire the thousands of additional staff necessary to provide such data and to enforce regulations has in the past made this unfeasible. This fact, combined with the legal ramifications of native land claims and treaty rights, and potential political quagmires entailed by calls

from local communities and fishers associations for a greater say in management of the resource, indicates that a new paradigm in fisheries management is urgently required.

In such a new paradigm it is evident that LO-TEK will play a central and long overdue role. As Eythorsson (1993) argues, "Local traditional knowledge and local norms could therefore prove to be an important, or even a necessary supplement to scientific knowledge for the establishment of ecologically sound and socially just management of common property resources" (p. 140). In the opinion of development expert Arun Agrawal (1995), "The focus on indigenous knowledge and production systems represents a long overdue move. It represents a shift from the preoccupation with the centralized, technically oriented solutions of past decades..." (p. 415). This section examines various suggestions made by experts in LO-TEK for integrating this system with conventional science. After a discussion of ecological micro-management, the concept of "parametric management" is introduced as a conceptual framework for accomplishing this integration.

3.1 - Ecological Micro-Management (EMM)

Numerous studies have demonstrated the existence of sophisticated cultural systems for environmental management and self-regulation by indigenous peoples (see for example Blackburn and Anderson 1993). Central to LO-TEK is its application in local resource settings, a concept best described as ecological micro-management (EMM). Fisheries EMM involves habitat modification and enhancement, the creation and/or maintenance of spawning areas, the removal of obstacles to fish migration (as practised by Mi'kmaq gaspereau harvesters, the Gitksan and Wet'suwet'en salmon harvesters described by Morell (1989), and by the Nuxalk in Hipwell (1997)), and the seeding of shellfish into public beds as practised by the Mi'kmaq Eskasoni Fish and Wildlife Commission and the clam fishers described in McCay (1989). Awareness of local conditions is a prerequisite to the success of such techniques.

EMM also involves finely-tuned harvesting practices that can respond to micro-level variations in stock levels and reproductive rates. In the case of fisheries, large-scale approaches to harvest management have frequently lead to ecological disaster because

> large, mobile and efficient fleets can easily overharvest a stock, and also cannot efficiently harvest small surpluses from minor stocks without a very high degree risk of overharvesting. For this reason many small stocks are not harvested or effectively managed (Richardson and Green 1989: 260).

By contrast, EMM allows the efficient harvest of small surpluses. I found evidence of this during a research project in Cape Breton during the summer of 1997. Mi'kmaq traditional gaspereau harvesters set up weirs at the entrances to small ponds, and depending on micro-level (i.e. pond to pond) variations in stock levels and empirically-derived information on reproductive rates, adjust harvest levels accordingly, taking only what the fisher in charge of the weir deems to be a "surplus". Paul (1993) cites ethnographic evidence that as early as 1593 (and probably much earlier) the Mi'kmaq constructed artificial fish ponds. The practise evidently continues almost 500 years later: many of the ponds I visited appeared to be made by humans, and yet were used by wild gaspereau stocks for breeding.

Industrial fleets harvesting fish in open waters are incapable of the kind of refined harvesting technique employed by the Mi'kmaq. Since conventional science-based fisheries management sets quotas based on average populations, pond-specific stocks (according to Mi'kmaq fishers, gaspereau return to the same breeding area from which they hatched) can be wiped out if their specific sustainable harvest rate is below the centrally-determined average for the larger population. This applies equally to the salmon fisheries (Kearney 1989; Richardson and Green 1989). From this perspective, changes in

allocation to privilege such micro-level harvests seem also to be in order.

In most indigenous communities micro-level harvest regulations traditionally took ritual form. Swezey and Heizer (1993) describe the ritual regulation of the salmon harvest among Northern Californian coastal and upstream indigenous nations. Citing dozens of ethnographic accounts by anthropologists and other social scientists from the late 19th century to the 1940s, they found a "remarkable similarity of form and function throughout Native California" of first salmon rituals that were "overtly managerial, conservational, or organizational in effect" (p. 300). Socio-cultural control by formulists (ritual specialists responsible for managing the salmon harvest) included restrictions on harvest times and allowing sufficient escapement based on micro-ecological conditions. During the salmon spawning runs, weirs were not constructed until a large number of salmon had passed upriver. Decisions regarding when to start the harvest were made at the time of the beginning of the run, based on the formulists' intuitive analysis of empirical observations of salmon numbers and health, and micro-ecological conditions (e.g. water levels). Similarly, weirs were periodically opened to allow salmon to pass through at times once again determined by the formulists (often on a nightly basis). Self-regulation of the salmon harvest took into account the needs of upstream nations as well as the necessity of allowing the escapement of a large and healthy spawning stock. Acheson and Wilson (1996) note that EMM rules are enforced by informal community pressure. Voluntary compliance with these culturally-developed harvest regulations was usually universal.

On the Pacific Coast of North America, after centuries of intensive harvesting (salmon was the primary staple food of indigenous nations whose combined population was in the hundreds of thousands), European ethnographers in the 19th century reported that the streams were so full of salmon that their horses were afraid to ford them (Swezey and Heizer 1993). This abundance is surely testimony to the effectiveness of EMM.

Pinkerton (1989b) suggests that co-management is a way for modern government managers to come to terms with

> ...often pre-existing local systems of management... [which] are often self-regulating, that is, they have already worked out a long-term, stable relationship with local stocks which allows a sustained yield (p. 13-4).

Berkes et. al. 1991 provide a more detailed definition of these self-regulating local-level management systems:

> They are consensus-based and enforced through local sanctions... [T]hey are not based on science but rather on customary practice, cultural tradition and the local knowledge of land and animals (p. 12),

noting that some government managers still do not regard local-level systems as management systems. Yet according to Rettig et. al. (1989), "All the evidence points to conservation practices having become thoroughly institutionalized into both [indigenous] secular authority and spiritual life long before European contact" (p. 280), or as Ostrom (1990) puts it, "communities of individuals have relied on institutions resembling neither the state nor the market to govern resource systems with reasonable degrees of success over long periods of time" (p.1).

3.2 - Parametric Management

In a recent article, anthropologist James Acheson and resource economist James Wilson introduce their "parametric model" of fisheries management (Acheson and Wilson 1996). Premised on the theory

that the sizes of fish stocks change chaotically within certain limits, they conclude that stock-recruitment models developed by conventional science and employed by fisheries managers are inadequate. Stock recruitment models are based on the presupposition that marine ecological systems and fish populations are ordered, balanced, and in dynamic equilibrium, yet Acheson and Wilson argue that the evidence is ambiguous and does not demonstrate that stock recruitment relationships exist as supposed. The problem is that stock-recruitment models "lead unerringly to policies designed to regulate the quantity of fish that can be taken" (p. 580, emphasis added) through the imposition of top-down management of large units.

Acheson and Wilson suggest that when fish stocks are understood as chaotic systems, a number of things become apparent. Chaotic systems vary within specifiable limits, and are extremely sensitive to initial conditions (i.e. qualitative factors regarding system parameters). Minute changes at t1 cause huge variations at tx. Given the deterministic nature of chaotic systems, one should in theory be able to predict the eventual effect of a given change. However, the complexity of feedback mechanisms and the number of interrelationships is so large that "a huge amount of accurate, fine-grained, continuously updated data would be necessary to make accurate prediction possible" (p. 584). All that can be predicted is that if system parameters are maintained, populations will continue to vary chaotically within specifiable limits. If system parameters are enhanced (e.g. through habitat improvement), then the upper limits may be increased.

Given the chaotic nature of marine ecosystems, accurate prediction of the outcome of quantitative approaches such as quota to achieve maximum sustainable yield or maximum economic yield is also impossible. As argued in Section 3.1 above, this inherent lack of accuracy means that quota systems, especially when applied to large management areas, can easily lead to economic inefficiencies or ecological disaster.

Acheson and Wilson cite several studies that link chaos and complexity with changes in fish stocks, the behaviour of fishers, and the nature of maritime communities. Folk fishing communities, they argue, operate on the assumption that ocean systems are complex. The technologies and techniques employed for harvesting by local communities are therefore adapted for parametric management. An example of this is Eythorsson's (1993) account of the Sami fjord fishers, whose gill nets were designed to allow biggest fish to escape, ensuring the survival of a healthy breeding stock. Acheson and Wilson examined 36 fishing communities, eight of them in industrialized countries where management is centralized and based on stock-recruitment models, and 28 of them in developing countries where local EMM is practised. They conclude that while scientific management depends heavily on the imposition of quotas, etc. to regulate how much fishing is done, under EMM, there is a greater emphasis on technology restrictions, protection of breeding stocks and spawning areas and a conservation ethic, to regulate how fishing is done. Moreover, EMM is by definition applied to small management units. Acheson and Wilson believe that small units have two advantages:

> Management of small units eases the problems of obtaining information on biological processes, since it is easier to learn the intricacies of a small zone than a large one. Local-level management would presumably be more able to frame rules that fit local conditions that take into account local practices and norms. This in turn should result in a higher degree of political support (p. 589).

The article concludes that the EMM practices arising from LO-TEK may be "the key to solving very serious problems with the world's fisheries" (p. 589), and that "fisheries management in the West would be well advised to emulate management practices of a large number of peasant and tribal societies, which are more consistent with fisheries biology and the chaotic nature of marine resources" (p. 579). Regulation should focus on the maintenance of regular biological processes or system parameters such as spawning potential, growth rates, habitat and migration paths, through the establishment of rules on how fishing is done in relatively small areas. As shown in Section 3.1,

knowledge of system parameters at small geographical scales is the speciality of LO-TEK, and the development of appropriate practices to maintain these parameters characterizes LO-TEK-based EMM. However, the authors do concede that when parametric management is applied to modern industrial fisheries, for example through restrictions on "dragger" technologies which damage habitat, it must take a hierarchical form. Successfully adopting "folk management" or EMM techniques into a new paradigm of parametric fisheries management will require the integration of LO-TEK and conventional science.

4.0 - INTEGRATING CONVENTIONAL SCIENCE AND LO-TEK

Under the Oceans Act of 1997, "Integrated Coastal Zone Management" (ICZM) became part of federal fisheries policy (FOC 1997a). As defined by FOC, ICZM explicitly includes the integration of LO-TEK and conventional science (FOC 1997f). This section will discuss some of the most important considerations in accomplishing such an integration. A key underlying factor in all of these is attention to scale.

A clear geographic pattern becomes evident from a detailed survey of ethnographic and scientific research into LO-TEK-based resource management, or EMM, among indigenous and non-indigenous communities. EMM represents the most efficient and productive management technique at small geographical scales, by enabling discrete and flexible decisions to be made regarding harvest regulations, and habitat enhancement such as removal of impediments to spawning migration (see section 3.1 above).

At the same time, the insights of LO-TEK regarding system parameters can inform conventional science-based management at larger scales. This notion is highlighted by an anecdote related to me by a member of the Eskasoni Fish and Wildlife Commission in Cape Breton. In the 1980s, the Department of Fisheries and Oceans decided to allow commercial seiners to harvest herring in management unit 4VN off the north-east coast of Cape Breton Island, which they did without consultation with the Mi'kmaq communities around the shores of the nearby Bras D'or Lake. The Bras D'or is, according to Mi'kmaq LO-TEK an extremely important hatchery and nursery for many North Atlantic fish species. Moreover, Mi'kmaq LO-TEK identifies the north-east coast of Cape Breton as the migration path used by herring and other species travelling to the Bras D'or Lake to spawn. The Mi'kmaq subsequently brought their concerns to the attention of FOC managers, but seiner activity in 4VN was allowed to continue. Mi'kmaq elders subsequently noticed a precipitous decline in the number of spawning herring in the Bras D'or Lake, which they blamed on the presence of the seiners in 4VN.

Given the sensitivity of chaotic systems to changes in initial conditions (system parameters), it is likely that the qualitative impact (disruption of reproduction) of the interception of spawning herring in 4VN would have had a more profound impact on herring population levels than the quantitative impact of overall herring quotas. While it is clear that conventional science is required to assess macro-level populations and allocate harvest quotas to large commercial interests operating in the open sea, this anecdote highlights the importance of LO-TEK in providing information that may be beyond both the ken and the capacity of conventional scientists.

4.1 - Achieving Integration

Johnson (1992) identifies four conditions for the successful integration of LO-TEK and conventional science in resource management:

1. Financial and administrative support for documentation of LO-TEK before it is lost through

attrition (e.g. death of elders).

2. Recognition of alternate knowledge systems.

3. Support for cross-cultural education of both conventional scientists and LO-TEK holders

4. Political recognition of aboriginal land claims

I would add a fifth point: the heeding of calls by non-natives for community empowerment (see Section 2.1 above).

As argued earlier, there remains considerable resistance among conventional scientists to accepting the validity of LO-TEK. Howes and Chambers (1980) make four recommendations for measures to decrease this resistance:

1. Rural exposure for research staff

2. Local level influence on research priorities

3. Starting with indigenous practice in designing research instruments (though they warn that indigenous practice may be so complex as to render reproduction under controlled research conditions difficult).

4. Experimental work in rural conditions.

Local resource users (ecological micro-managers) should also be employed as research collaborators. This would have the dual benefit of providing managers with increased access to local data while simultaneously encouraging the continuation of EMM.

4.1.1 - The Need for Equality

The expert consensus is that co-management regimes must integrate LO-TEK and afford it status equal to conventional scientific knowledge (e.g. Winn 1991; Pinkerton 1989a; Usher 1986; Cizek 1990; Eythorsson 1993; Freeman and Carbyn 1988). Yet Johnson (1992) and Howes and Chambers (1980) note that when LO-TEK and conventional science meet the latter tends to suppress the former, either by denying its validity or incorporating it without acknowledgement. Agrawal (1995) has argued that it may be a false dichotomy, or at least unproductive to view LO-TEK and conventional science as different knowledge systems. Yet this dichotomy is perpetuated in part because

> "Junior field extension staff, for example, being low in the government service, have a vested interest in exaggerating differences between themselves and local people, and the distinction between 'superior' scientific and 'inferior' indigenous knowledge protects and legitimizes their status." (Johnson 1992: 322)

In light of Acheson and Wilson's comparison of EMM with the sciences of chaos and complexity, LO-TEK may be better considered a branch of human scientific understanding of the natural world. Broadening the definition of science to include LO-TEK will mean that both local communities and central governments can "economize on the use of scarce trained scientific manpower or extend the range of observations upon which science can draw" (Johnson 1992: 327). As Eythorsson (1993) argues, "...there is no need for a contradiction between traditional knowledge and scientific knowledge. The two types of knowledge should be complementary, and resource managers should gain from

using both types as a basis for management regimes" (p. 134).

4.1.2 - Resolving Contradictions

A pervasive concern among managers and local communities alike is how possible contradictions between LO-TEK and conventional science might be resolved. With reference to the anecdote about seiners in Unit 4VN cited in Section 4.0, what if fisheries biologists had contradicted the Mi'kmaq contention that 4VN covered a herring migration route? This type of situation poses difficulties which do not appear to have been adequately resolved in the literature.

A few clues in this regard may be found with reference to the Popperian principle of falsification. As was discussed in Section 1.1, conventional science can not establish facts conclusively. Instead, hypotheses are held to be "probably" true until falsified. As such, if LO-TEK claims are viewed as scientific hypotheses, then the onus is on conventional scientists to disprove them before they can be rationally rejected. Disproving a hypothesis is more than a matter of disagreeing with it, a body of experimental data must be developed that clearly falsifies a given hypothesis. Conventional scientists might attempt to prove, for example, that herring do not migrate at all, or through the use of fish tags attempt to establish that all the herring in 4VN are moving away from the Bras D'or Lake, not toward it.

So how should fisheries managers respond in a situation where an alternate hypothesis has been proposed by LO-TEK holders, but not yet falsified by conventional science? This question is not a scientific one, but rather one of policy. The Oceans Act of 1997 provides clear direction in this regard: "The national strategy will be based on the principles of... (c) the precautionary approach, that is, erring on the side of caution" (FOC 1997a: Part II, Section 30). "Erring on the side of caution" means that if LO-TEK claims entail precautionary policy measures, these measures should be implemented immediately and only changed if the LO-TEK claims are subsequently falsified by accepted conventional scientific methods. By this reasoning, in the case of 4VN all seiner herring quotas should have been immediately revoked by FOC until Mi'kmaq claims had been rigorously investigated by biologists, and not reinstated unless this rigorous investigation clearly falsified the contention that 4VN was part of the herring spawning migration route. Adopting a "true until proven false" attitude toward LO-TEK claims, and making management decisions accordingly would at worst cause interim economic inconvenience if such claims are subsequently falsified, and at best avert potential ecological disasters if they are not. Erring on the side of caution is not just an ecologically good idea: since January 31, 1997, it's the law.

4.1.3 - Control Issues

It is unlikely that holders of LO-TEK will be interested in sharing their knowledge with government managers until issues of control over this knowledge and its application are resolved. For example, why would local fishers reveal sites or times of aggregation or migrations if this knowledge could then be used by large commercial fishing interests to compete for the resource? With regard to indigenous communities, Doubleday (1993) argues that "without addressing fundamental issues like self-determination, restitution of lands and resources, and compensation, how can power be shared in a way which will ensure that traditional knowledge will not be misunderstood or misused?" (p. 49). This sentiment has been echoed by Chief Robert Wavey (1993):

> Maintaining complete indigenous control of traditional land use information is a cornerstone in developing a link between traditional ecological knowledge and science. This ensures that indigenous peoples develop the skills and capacity to benefit from the growing interest in traditional ecological knowledge. Development of the capacity for indigenous peoples to independently respond to and

> directly participate in the resource management activities arising from the application of traditional ecological knowledge is also required (p. 15).

Similarly, Johnson (1992) argues that the integration of LO-TEK and conventional science is clearly linked to the question of political power. As outlined in Section 2 above, the most feasible way of addressing these power and control issues is some form of formal co-management agreement explicitly addressing the control and use of LO-TEK data, and devolving management responsibilities to micro-geographical units identified by coastal communities.

4.2 - Accessing LO-TEK in Coastal Communities

The problem remains of how to gain access to LO-TEK in order to input it into management systems. For Howes (1980), elders represent the best sources of knowledge of change over time, due to the length of their personal experiences in natural settings. Eythorsson (1993) argues that elders develop cognitive maps of areas used for resource extraction and other activities, which in the case of Sami fjord fishers, include even the topography of the ocean floor. Similarily, women in local communities also possess specialized knowledge of ecosystem interactions and should be involved in the documentation of such information.

Johannes (1993) identifies four areas of focus for LO-TEK research:

1. Taxonomic: learning local names for animal, plant, soil and rock taxons. This helps to lessen the danger of overlooking the importance of certain ecosystem components as food, medicine, structural material, tools, soil-improvers, totems, etc. when making management decisions.

2. Spatial: identifying aggregation sites, migration routes, etc. In this regard mapping exercises involving local people are often more productive than site inventories done by outside researchers.

3. Temporal: determining the timing of certain significant biological events, including site aggregations and spawning activity.

4. Social: studying the way local people "perceive, use, allocate, transfer, and manage their natural resources... [LO-TEK] cannot be used properly in isolation from the social and political structure in which it is imbedded" (p. 35).

Methods for accessing LO-TEK include discourse analysis, formal eliciting, and semi-directed interviews (Mailhot 1993) as well as mapping exercises (Brody 1988; Johannes 1993). Howes and Chambers (1980) argue that one of the best methods for gaining access to LO-TEK is for government personnel to work alongside local harvesters/workers. For this reason, in order for resource managers to access LO-TEK in local communities, they may need to employ social scientists (anthropologists, community planners, sociologists, geographers, etc.) with an expertise in this social and political context to act as intermediaries or "liminal personae" (DeWalt 1994). When dealing with indigenous communities, it may be preferable to hire aboriginal staff, preferably of the same nation.

Even in cases among indigenous nations where the transmission of LO-TEK has been severely interrupted by cultural dislocations such as Residential Schooling or depopulation due to disease or other factors, ethnography can reconstruct ritual practices that where almost universally practised among coastal indigenous nations. In some cases, particularly among East Coast nations where European colonization occurred much earlier, much of this data is only available through archival research into the accounts of earlier researchers who were able to interview Elders who themselves

had direct experience of LO-TEK practices. Nonetheless, among most indigenous nations, LO-TEK is still passed on in some form, continually revised and updated, from generation to generation. On both coasts, elders still survive who can provide first-hand accounts of cultural practices encompassing LO-TEK.

Natural scientists must work with social scientists to ensure ecological information provided by LO-TEK holders is properly understood (Johnson 1992; Johannes 1993). There is also a need for cultural sensitivity and language training for scientific researchers (Johnson 1992; Spak 1995), along with scientific training for local people (Johnson 1992; Weeks and Packard 1997).

As most of the authors cited in this study argue, there is an urgent need for extensive research programs into LO-TEK by the federal and provincial agencies mandated to manage the use and conservation of natural resources, to ensure that this information is not lost to the communities which developed it, and to humanity as well.

5.0 - CONCLUSION

The Oceans Act calls for the development of Integrated Coastal Zone Management (ICZM), including

- **the integration of all values - economic, environmental, social and cultural in decision making**
- **the integration of many forms of knowledge, both traditional [LO-TEK] and scientifically derived... (FOC 1997f).**

LO-TEK and conventional scientific approaches to knowledge differ in some regards, yet also share numerous commonalties. Limitations in both systems, and their complementary areas of expertise underscore the need for achieving some form of synthesis between them. Yet since power and knowledge are inseparable notions, bringing LO-TEK "back in" to fisheries management will entail addressing issues of political empowerment.

Co-management is the term used to describe arrangements where a significant degree of decision-making power is devolved from central governments to local communities. While a realtively new approach, there exist numerous examples of co-management regimes in Canada and around the world. Two things become clear from a study of these examples: first, co-management is only likely to be successful where LO-TEK is afforded equal status to conventional science, and where this status is reflected at the level of management decisions; conversely, because of the socially-embedded nature of LO-TEK, its integration with conventional science is unlikely to be successful in the absense of shared power such as that represented by co-management arrangements.

Within the context of a co-operative approach to fisheries resource management, LO-TEK "mutable immobiles" mean that ecological micro-management is usually superior to conventional scientific at small geographical scales. Conventional science, on the other hand, with its "immutable mobiles", can frequently provide data at geographical scales beyond the capabilities of local communities. "Mutable mobiles" need to be developed, primarily through the establishment of effective channels of communication and an attitude of humility among both local communities and conventional scientists, that will allow insights from both branches of knowledge to inform understandings and practices at local and macro geographical scales. When contradictions between the two systems occur, decisions must be made which reflect the federal government's committment to "err on the side of caution": conservation of ecological processes must take precedence over economic considerations, and the economic

needs of local communities must take precedence over large commercial interests.

The Oceans Act represents a bold and progressive move in the management of marine resources:

> "The Minister, in collaboration with other ministers, boards and agencies of the Government of Canada, with provincial and territorial governments and with affected aboriginal organizations, coastal communities and other persons and bodies, including those bodies established under land claims agreements, shall lead and facilitate the development and implementation of a national strategy for the management of estuarine, coastal and marine ecosystems in waters that form part of Canada or in which Canada has sovereign rights under international law" (FOC 1997a: Part II, Section 29).

In addition to the official policy of "erring on the side of caution" (Part II, Section 30), the Act also explicitly recognizes of the need to involve indigenous nations and other coastal communities not merely in a consultative, but in a collaborative role:

> The Oceans Management Strategy section of the Oceans Act outlines a new approach to managing oceans and their resources. The concept is based on the premise that oceans must be managed as a collaborative effort among stakeholders (FOC 1997c).

This report has outlined perhaps the most important aspect of such a collaborative effort: the existence of LO-TEK among those communities, and the vital role of incorporating this LO-TEK into integrated resource management. The next stage will be to practically implement these recommendations into policy. It would be productive to establish a series of demonstration projects where LO-TEK and conventional science are used equally in integrated approaches, with a view to creating a new paradigm in fisheries management.

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